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SEISMIC BEHAVIOUR OF REINFORCED CONCRETE FRAME WITH DIFFERENT INFILLS

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ABSTRACT

The present study investigates the seismic performance of reinforced concrete framed building with a bare frame, equivalent diagonal strut, R.C wall and shear wall. The seismic behaviour of a 10-storey building investigated using response spectrum analysis. Equivalent diagonal strut methodology is used to represent the behaviour of infill walls, whilst the well-known software package ETABS is used for implementing all frame models and performing the analysis.

In this investigation such as maximum displacement, maximum drift, storey shear, base shear and time period for the bare frame as well as the equivalent diagonal strut, R. C wall and shear wall are presented in a comparative way. The results of the study indicate that the interaction between infill walls and frames significantly change the responses of buildings during earthquakes compared to the results of the bare frame building model. While comparing base shear, the value drastically decreases for the bare frame coming to the base shear for other models uniformly decreases. Whereas comparing storey drift, the value considerably decreases for the bare frame coming to the storey drift for other models uniformly increases.

KEYWORDS: Bare Frame, Equivalent Diagonal Strut, R. C Wall, Shear Wall & Response Spectrum Analysis

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Original Article

INTRODUCTION

Nowadays, Natural Hazards and Disasters become common in our country (India). Therefore Natural Hazards and Disasters classified into several different categories. There are geologic hazards (Earthquakes, volcanic eruptions, Tsunami, Landslides, Floods, Subsidence and Impacts with space objects) Atmospheric Hazards (Tropical Cyclones, Tornadoes, Droughts, Severe Thunderstorms and Lightening) and other Natural Hazards (Insect infestations, Disease epidemic sand Wildfire). From the above natural hazards and disasters, Earthquakes is considered in these project. An earthquake may be defined as a wave-like motion generated by forces in constant turmoil under the surface layer of the earth (the lithosphere), travelling through the earth's crust. It may also be defined as the vibration, sometimes violent, of the earth's surface as a result of a release of energy in the earth's crust. This release of energy can be caused by sudden dislocation of the crust, volcanic eruptions, or even explosions created by humans. Dislocations of crust segments, however, lead to the most destructive earthquakes. In the process of dislocation, vibrations called seismic waves are generated. These waves travel outwards from the source of the earthquake at varying speeds, causing the earth to quiver or ring like a bell or tuning fork. During an earthquake, enormous amount of energy are released. The size and severity of an earthquake are estimated by two important parameters – intensity and magnitude. The magnitude is a measure of the

amount of energy released, while the intensity is the apparent effect experienced at a specific location. For measurement of an earthquake, an instrument is seismographs. Classifications of seismographs of three types are displacement seismograph, velocity seismograph, the acceleration seismograph. Causes of Earthquakes are Natural source and Man-made sources. The natural sources are the Tectonic earthquake, Volcanic-earthquakes, and Rock faults, The Man-made sources are Controlled sources (explosives), Reservoir-induced earthquakes and Mining Induced. Seismic Waves is defined as large strain energy released during an earthquake travels as seismic waves in all directions through the Earth's layers, reflecting and refracting at each interface. There are two types of seismic waves are Body waves, it consists of Primary Waves (P-waves) and Secondary Waves (S-waves) and Surface waves, it consists of Love waves and Rayleigh waves. After selecting the structural model, it is possible to perform analysis to determine the seismically induced force in the structures. The analysis can be performed on the basis of the external action, the behaviour of the structure or structural materials, and the type of structural model selected. Based on the type of external action and behaviour of structure, the analysis can be further classified as linear static analysis, linear dynamic analysis, non- linear static analysis, non- linear dynamic analysis. Whereas linear static analysis or equivalent static analysis can be used for regular structures with limited height, linear dynamic analysis can be performed in two ways-either by the response spectrum method or by the elastic time-history method. The significant difference between linear static and linear dynamic analyses is the level of the forces and their distribution along the height of the structure. The non-linear static analysis is an improvement over linear static or dynamic analysis in the sense that it allows the inelastic behaviour of the structure, this method known as pushover analysis. Non-linear dynamic analysis or inelastic time history analysis is the only method to describe the actual behaviour of a structure during an earthquake. Reinforced concrete (RC) frame buildings with masonry infill walls have been widely constructed for commercial, industrial and multi-story residential uses in seismic regions. Masonry infill typically consists of bricks or concrete blocks constructed between beams and columns of a reinforced concrete frame. The masonry infill panels are generally not considered in the design process and treated as architectural (non-structural) components. Nevertheless, the presence of masonry infill walls has a significant impact on the seismic response of a reinforced concrete frame building, increasing structural strength and stiffness (relative to a bare frame). Different infill walls are considered in the project, according to IS: 875 (part 1), there are Common burnt clay bricks, Engineering bricks, and Heavy duty bricks. In this project by using response spectrum analysis with unreinforced masonry (URM) infill walls shall be modelled by using equivalent diagonal struts as below:

- Ends of diagonal struts shall be considered to be pin-jointed to RC frame.
- For URM infill walls without any opening, width was of equivalent diagonal strut shall be taken as one-third of the diagonal length d of the URM infill wall as shown in figure. According to IS: 1893-2016 (part 1), Clauses 7.9.2.2, page no: 48

The Objectives for this Dissertation Work are

- The main aim of this study is to find the performance of buildings with different wall during earthquake.
- In this study, bare frame, equivalent diagonal strut, R. C wall and shear wall are considered in modelling.
- To compare the storey drifts, storey displacement, lateral load, base shear, storey shear and time period for models.

- To find the difference of structural and non-structural element deformation.
- To suggest the optimized design and required structural elements in the buildings.

METHODOLOGY

- In the present study, the RC members and infill Walls are modelled using ETABS software.
- Response spectrum method of analysis is adopted for the analysis of the unfilled frame with and without opening and the results are compared.
- In this study, 10- storied building analysed with a bare frame, equivalent diagonal strut, R. C wall and shear wall.

MODELLING AND ANALYSIS

Table 1: Geometry Properties

Modelling building	10 storey
Plan view of structure	24 m X 24 m
No. of bays in X-direction Y-direction	3 no's 3 no's
Each bay width in X-direction Y-direction	8 m 8 m
Height of each floor(for all floor)	3 m
Each column size (for all floor)	600 mm X 600 mm
Each beam size (for all floor)	450 mm X 450 mm
Slab thickness	125 mm
Shear wall thickness	200 mm
Equivalent diagonal strut size	230 mm X 1000mm

Table 2: Material properties

Grade of the concrete (For columns,beams,slabs)	M20
Grade of the reinforcement	HYSD415
Unit weight of concrete	25 KN/m^3
Density of steel	7850 Kg/m^3
Unit weight of brick masonary	21.20 KN/m^3
Main Reinforcement used in structure Distribution reinforcement used in structure	20mm dia 8mm dia
Reinforcement used in shear wall	10 mm dia

Table 3: Earthquake Properties Details

Seismic zone	V
Zone factor	0.36
Importance factor	1.5
Soil type	II
Response reduction factor	5.0(SMRF)

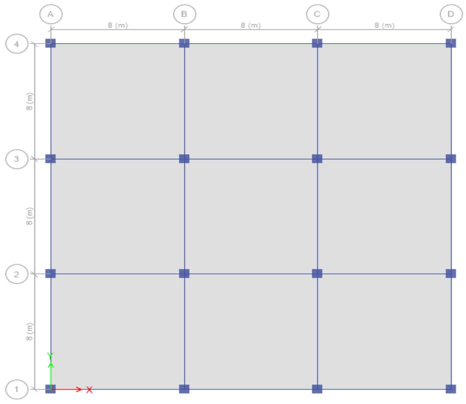

Figure 1: Plan View of Building

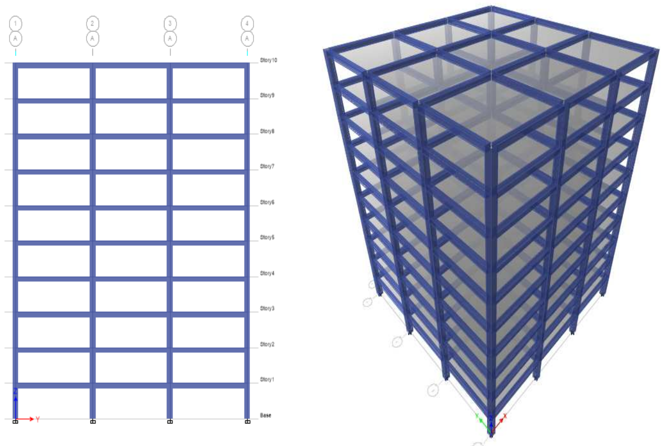

Figure 2: Elevation and 3D View of Bare Frame

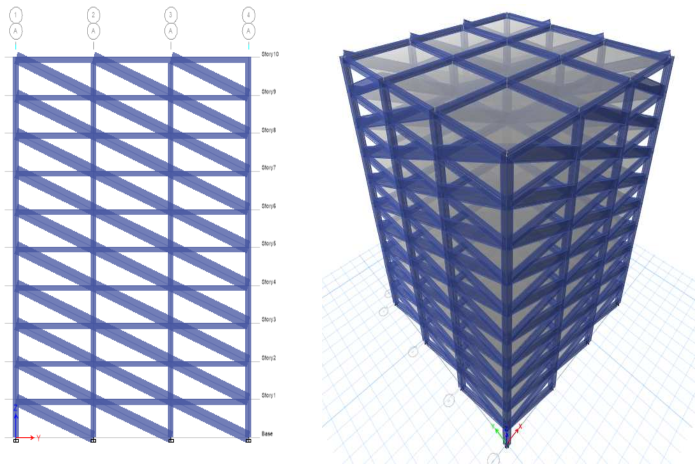

Figure 3: Elevation and 3D View of EDS

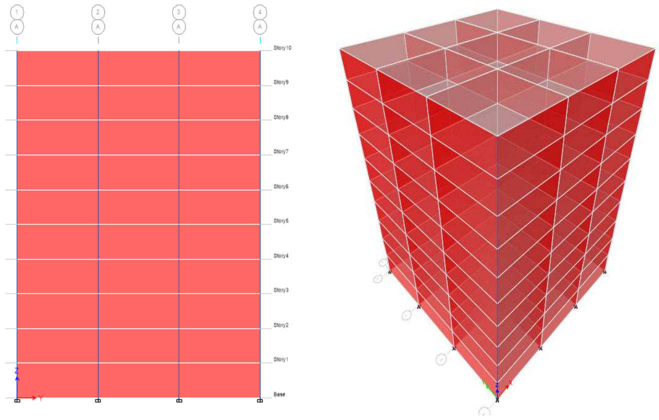

Figure 4: Elevation and 3D View of Shear Wall

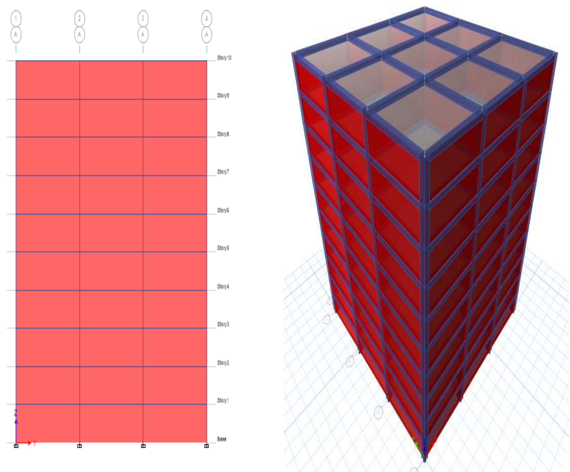

Figure 5: Elevation and 3D View of R. C wall

RESULTS AND DISCUSSIONS

Table 4: Bare Frame

Maximum storey displacement(mm)	68.08
Maximum storey drift(mm)	0.0033
Storey shear(KN)	476.87
Lateral force on stories(KN)	334.51
Base shear(KN)	2005.59
Time period(sec)	1.68

Table 5: Comparison of Maximum Storey Displacement for Equivalent Diagonal Strut, R. C Wall and Shear Wall

S. No	Openings	Diagonal Strut(mm)	R. C Wall(mm)	Shear Wall(mm)
1	0%	5.96	2.04	1.75
2	10%	5.86	2.13	1.82
3	20%	5.74	2.28	1.92
4	30%	5.64	2.42	2.03
5	40%	5.53	2.66	2.21
6	50%	5.42	2.98	2.45

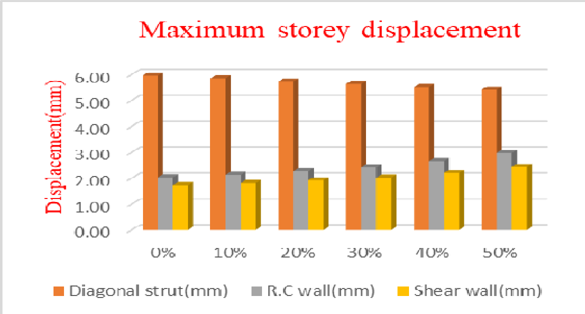

Figure 6: Show Comparison of Maximum Story Displacement for Equivalent Diagonal Strut, R. C Wall And Shear Wall

When comparing the maximum storey displacement with a bare frame drastically decreases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the maximum storey displacement is reduced by 65.77% and 70.63% for R. C wall and shear wall with openings.

Table 6: Comparison of Maximum Storey Drift for Equivalent Diagonal Strut, R. C Wall and Shear Wall

S. No	Openings	Diagonal Strut (mm)	R. C Wall (mm)	Shear Wall (mm)
1	0%	0.000259	0.000078	0.000044
2	10%	0.000254	0.000081	0.000045
3	20%	0.000248	0.000087	0.000047
4	30%	0.000243	0.000092	0.000050
5	40%	0.000238	0.000101	0.000053
6	50%	0.000232	0.000114	0.000058

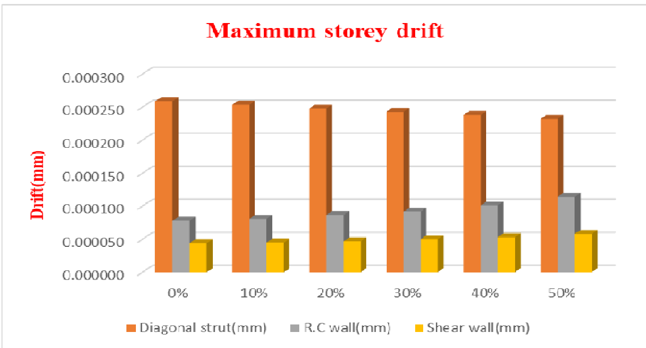

Figure 7: Show Comparison of Maximum Storey Drift for Equivalent Diagonal Strut, R. C Wall and Shear Wall

When comparing maximum storey drift with a bare frame drastically decreases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the maximum storey drift is reduced by 69.88% and 83.01% for R. C wall and shear wall with openings.

Table 7: Comparison of Storey Shear for Equivalent Diagonal Strut, R. C Wall and Shear Wall

S. no	Openings	Diagonal Strut(KN)	R. C Wall(KN)	Shear Wall(KN)
1	0%	1040.82	1529.38	1243.84
2	10%	1028.31	1486.81	1202.86
3	20%	1012.74	1433.34	1151.35
4	30%	1000.18	1390.46	1109.75
5	40%	983.28	1336.56	1057.35
6	50%	968.28	1282.35	1004.46

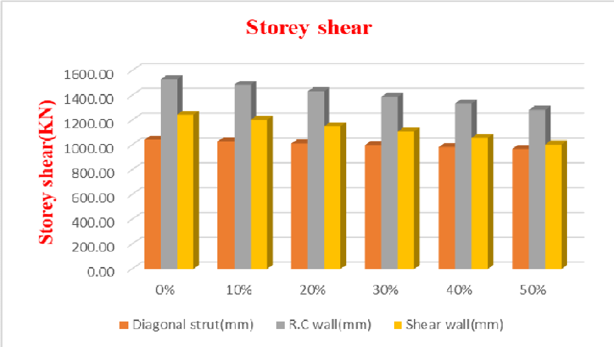

Figure 8: Show Comparison of Storey Shear for Equivalent Diagonal Strut, R. C Wall and Shear Wall

When comparing storey shear with bare frame considerably increases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the storey shear is increased by31.93% and 16.32% for R. C wall and shear wall with openings.

Table 8: Comparison of Lateral Load on Stories for Equivalent Diagonal Strut, R. C Wall and Shear Wall

S. no	Openings	Diagonal Strut(KN)	R.C Wall(KN)	Shear Wall(KN)
1	0%	1383.96	1835.95	1517.05
2	10%	1366.77	1779.98	1461.34
3	20%	1345.26	1709.91	1391.63
4	30%	1328.03	1653.77	1335.77
5	40%	1306.46	1583.44	1265.83
6	50%	1284.85	1512.94	1195.73

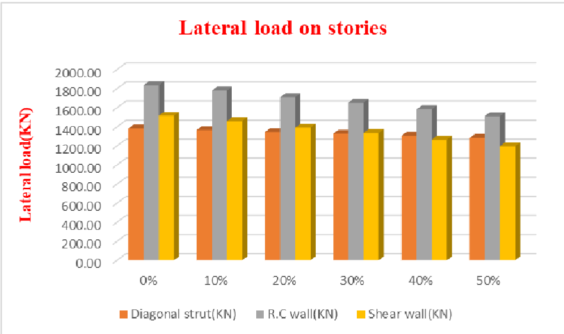

Figure 9: Show Comparison of Lateral Load on Stories for Equivalent Diagonal Strut, R. C Wall and Shear Wall

When comparing lateral load on stories with bare frame significantly increases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the lateral load on stories is increased by 24.62% and 8.77% for R. C wall and shear wall with openings.

Table 9: Comparison of Base Shear for Equivalent Diagonal Strut, R. C Wall and Shear Wall

S. no	Openings	Diagonal Strut(KN)	R. C Wall(KN)	Shear Wall(KN)
1	0%	5697.68	11280.70	9652.92
2	10%	5594.93	10853.58	9237.99
3	20%	5468.03	10319.02	8718.08
4	30%	5365.959	9892.69	8299.76
5	40%	5225.84	9360.83	7775.88
6	50%	5105.75	8832.95	7252.25

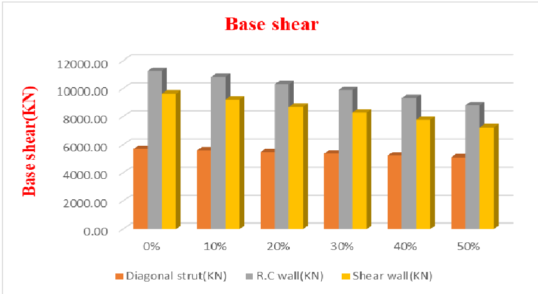

Figure 10: Show Comparison of Base Shear for Equivalent Diagonal Strut, R. C Wall and Shear Wall

When comparing base shear with a bare frame significantly increases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the base shear is increased by 49.49% and 40.97% for R. C wall and shear wall with openings.

Table 10: Comparison of Time Period for Equivalent Diagonal Strut, R. C Wall and Shear Wall

S. No	Openings	Diagonal Strut(sec)	R. C Wall(sec)	Shear Wall(sec)
1	0%	0.282	0.163	0.152
2	10%	0.27	0.167	0.155
3	20%	0.272	0.172	0.159
4	30%	0.275	0.178	0.163
5	40%	0.277	0.186	0.17
6	50%	0.28	0.197	0.179

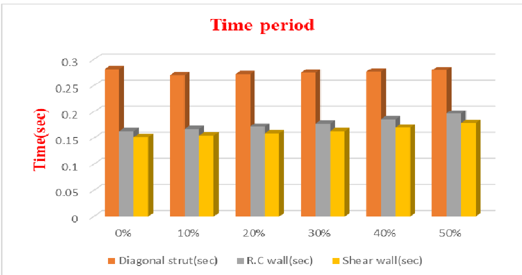

Figure 11: Show Comparison of Time Period for Equivalent Diagonal Strut, R. C Wall and Shear Wall

When comparing time periods with a bare frame significantly decrease for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the time period is decreased by 42.19% and 46.09% for R. C wall and shear wall with openings.

CONCLUSIONS

In this study, methods of analysis had been discussed and reinforced concrete, cement with a bare frame, equivalent diagonal strut, R. C wall and shear wall has been analysed for response spectrum analysis cases to determine the maximum storey displacement, maximum storey drift, storey shear, base shear and time period. Following conclusions are drawn from the above method and are listed below.

- When comparing the maximum storey displacement with a bare frame drastically decreases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the maximum storey displacement is reduced by 65.77% and 70.63% for R. C wall and shear wall with openings.
- When comparing maximum storey drift with a bare frame drastically decreases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the maximum storey drift is reduced by 69.88% and 83.01% for R. C wall and shear wall with openings.
- When comparing storey shear with a bare frame considerably increases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the storey shear is increased by31. 93% and 16.32% for R. C wall and shear wall with openings.
- When comparing lateral load on stories with bare frame significantly increases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the lateral load on stories is increased by 24.62% and 8.77% for R. C wall and shear wall with openings.
- When comparing base shear with a bare frame significantly increases for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the base shear is increased by 49.49% and 40.97% for R. C wall and shear wall with openings.
- When comparing time periods with a bare frame significantly decrease for equivalent diagonal strut, R. C wall and shear wall. Whereas equivalent diagonal strut with openings the time period is decreased by 42.19% and 46.09% for R. C wall and shear wall with openings.

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